Europa Clipper: Update to CAPS

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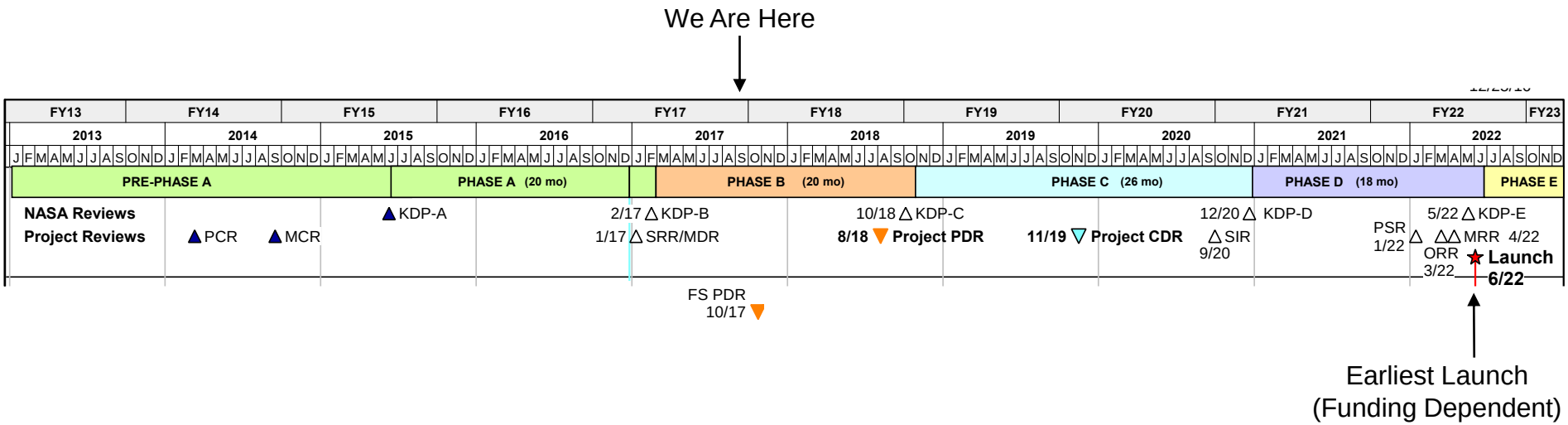
Overview

- PSG #5 Recap
- Project-Level Schedule
- PDR Schedule
- Tour Update
- Spacecraft Configuration
- Prototype Hardware
- Science Traceability and Alignment Framework

Project-Level Lifecycle Schedule



'Tis the Season for Preliminary Design Reviews (PDRs)

- **Propulsion Subsystem** 6/27-29/17 (Goddard)
- **Propulsion Module** 7/24-27/17 (APL)
- **Flight System** 10/17-20/17 (JPL)
- **Europa-UVS** 11/15-16/17 (SWRI)
- **PIMS** 12/6-7/17 (APL)
- **REASON** 12/11-12/17 (JPL)
- **EIS** 1/9-11/18 (APL)
- **SUDA** 1/17-18/18 (Univ. Colorado)
- **Solar Array** 1/22-23/18 (APL)
- **Power** 1/24-25/18 (JPL)
- **E-THEMIS** 1/30-31/18 (ASU)
- **ICEMAG** 2/14-15/18 (JPL)
- **Guidance, Navigation & Control** 2/7-8/18 (JPL)
- **Mechanical** 2/12-15/18 (JPL)
- **Thermal** 2/15-16/18 (JPL)
- **Radio Frequency Module / Telecom** 3/14-15/18 (JPL)
- **Radiation Monitors** 4/18 (APL)

- **Avionics** 4/30-5/4/18 (JPL)
- **MISE** 4/25-26/18 (JPL)
- **MASPEX** 5/15-16/18 (SWRI)
- **Fault Management** 5/15/18 (JPL)
- **Mission Design & Navigation** 6/4-5/18 (JPL)
- **Mission Operations System & Ground Data System** 6/6-7/18 (JPL)
- **Project PDR** 8/20-24/18 (JPL)

Spacecraft	Mission System
Payload	Project

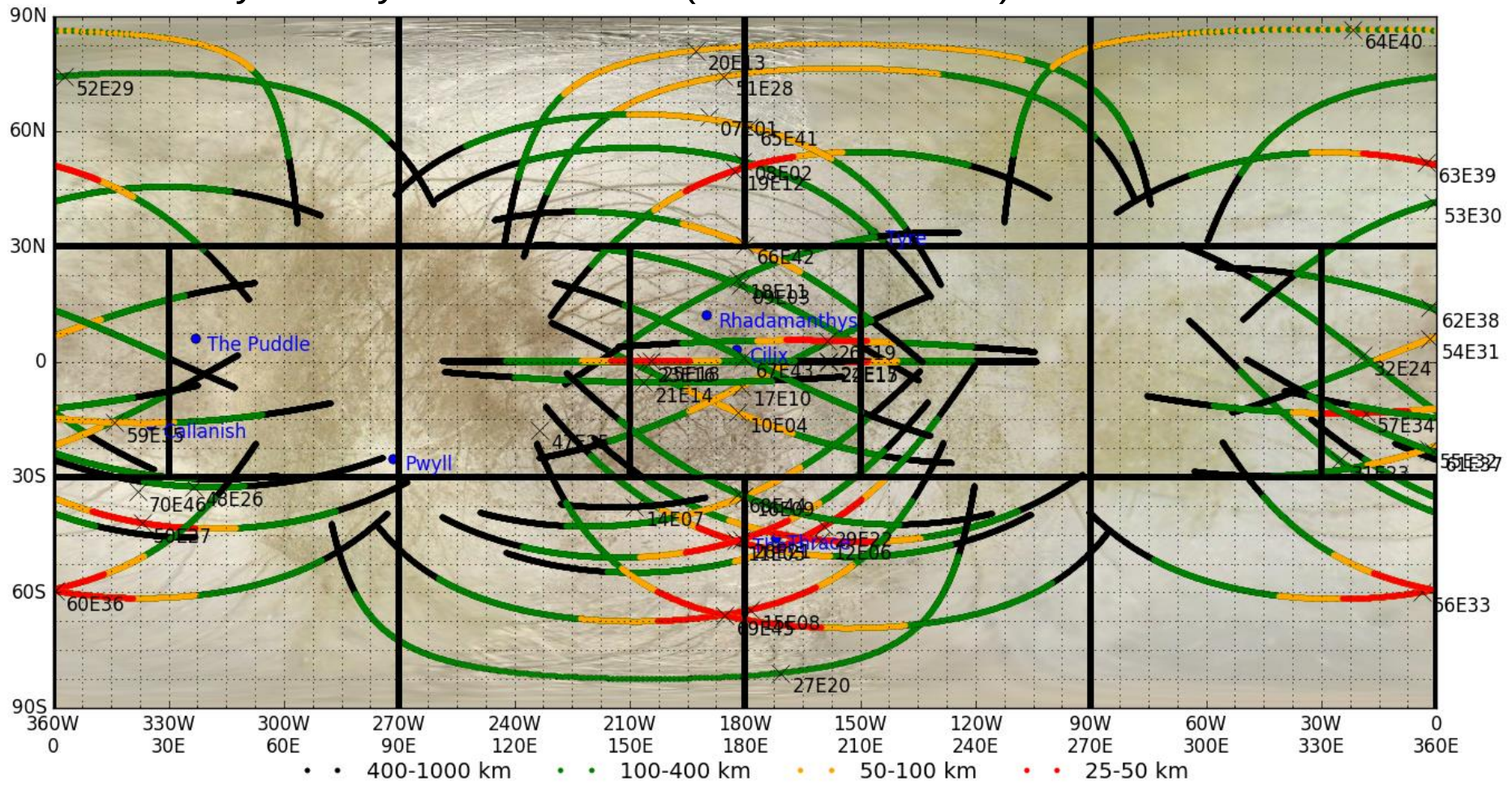
PSG Meeting #5 Recap

May 17–19, 2017

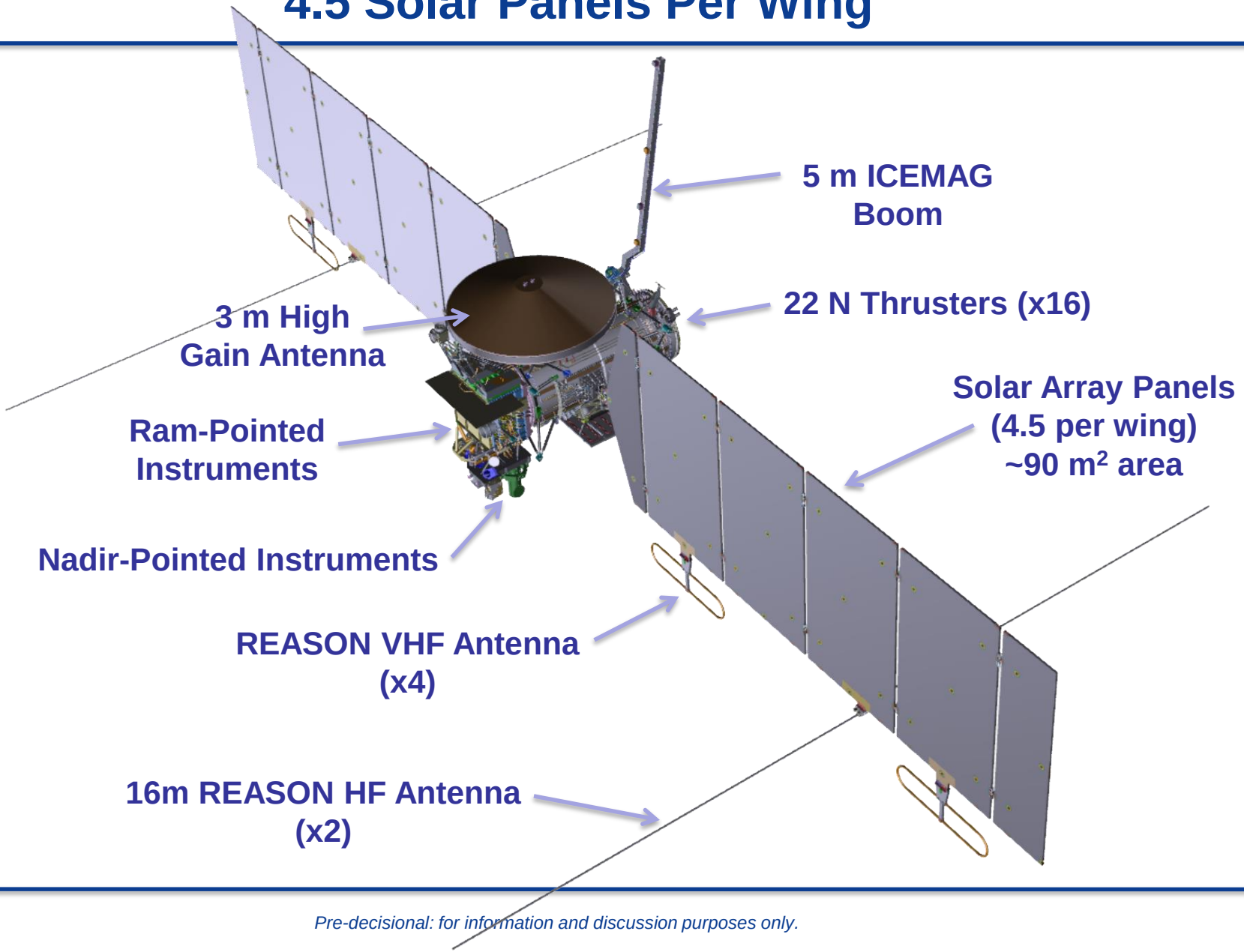
- Discuss science actions from MDR-SRR
- Evaluate tour options for Preliminary Design Reviews
- Outline Potential Collaborative Data Products
  - Quick-look and higher-level data products
- Establish foundation for Mission System plans:
  - Science observation planning & analysis tools
  - Data processing, analysis, & archiving
  - Feed-forward & latency
- Begin to define an Integrated Plume Search strategy
  - Established a new Plumes Focus Group
  - Co-Chairs: Matt Hedman & Carly Howett
- Confer on Rules of the Road development
- Discuss Project communications and remote collaborations
- Review Science Traceability and Alignment Framework for traceability from Level 1 science requirements to science observation types
- Nominate TWG Co-Chairs for rotation
  - Britney Schmidt (Habitability), Julie Rathbun (Geology), James Roberts (Interior), Murthy Gudipati (Composition)

Tour Update
17F12_v2

- Tweaked to include lower flybys in leading hemisphere
- Now fly directly over Callanish (<100 km altitude)!

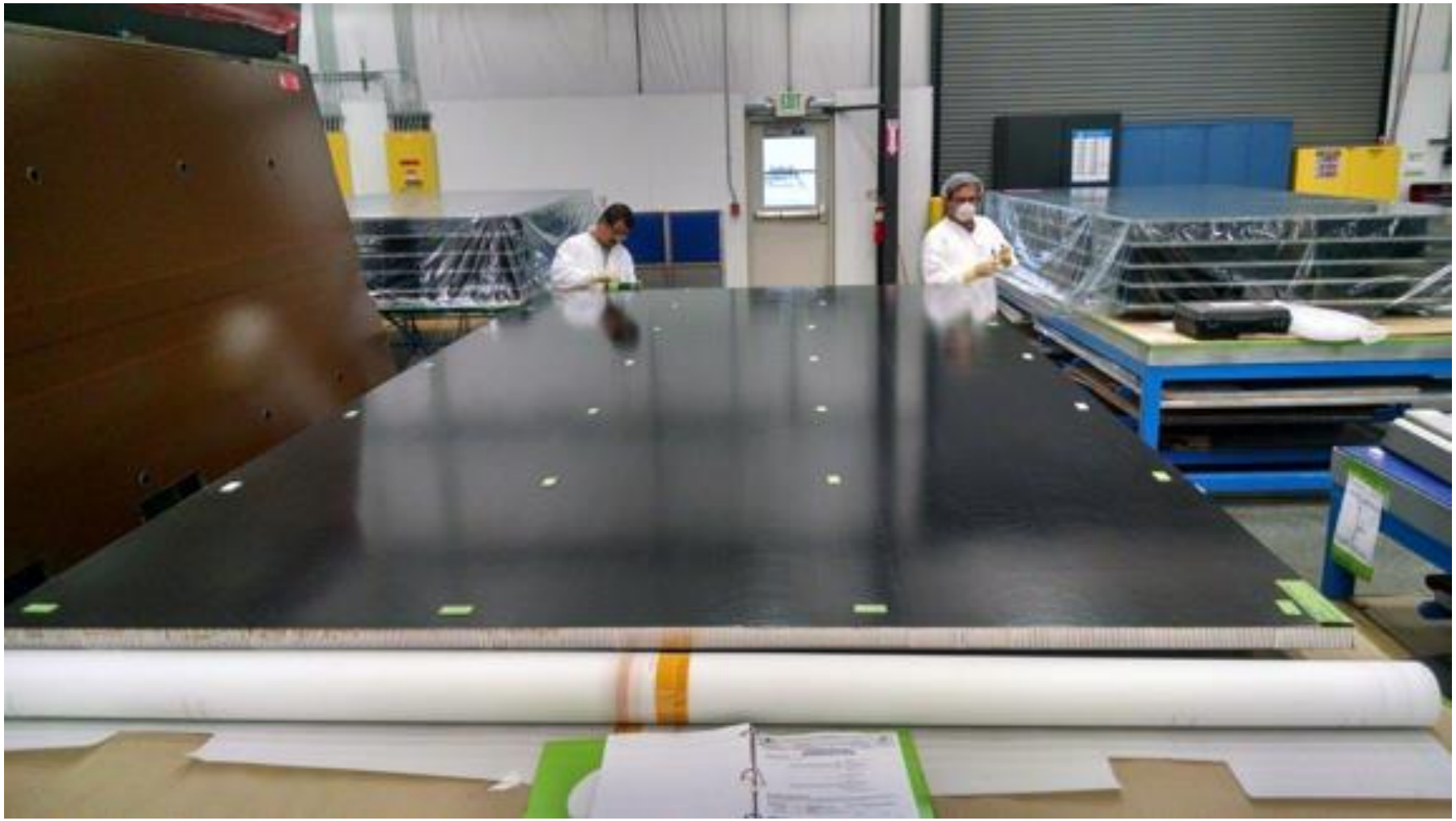


Spacecraft Configuration Update:
4.5 Solar Panels Per Wing



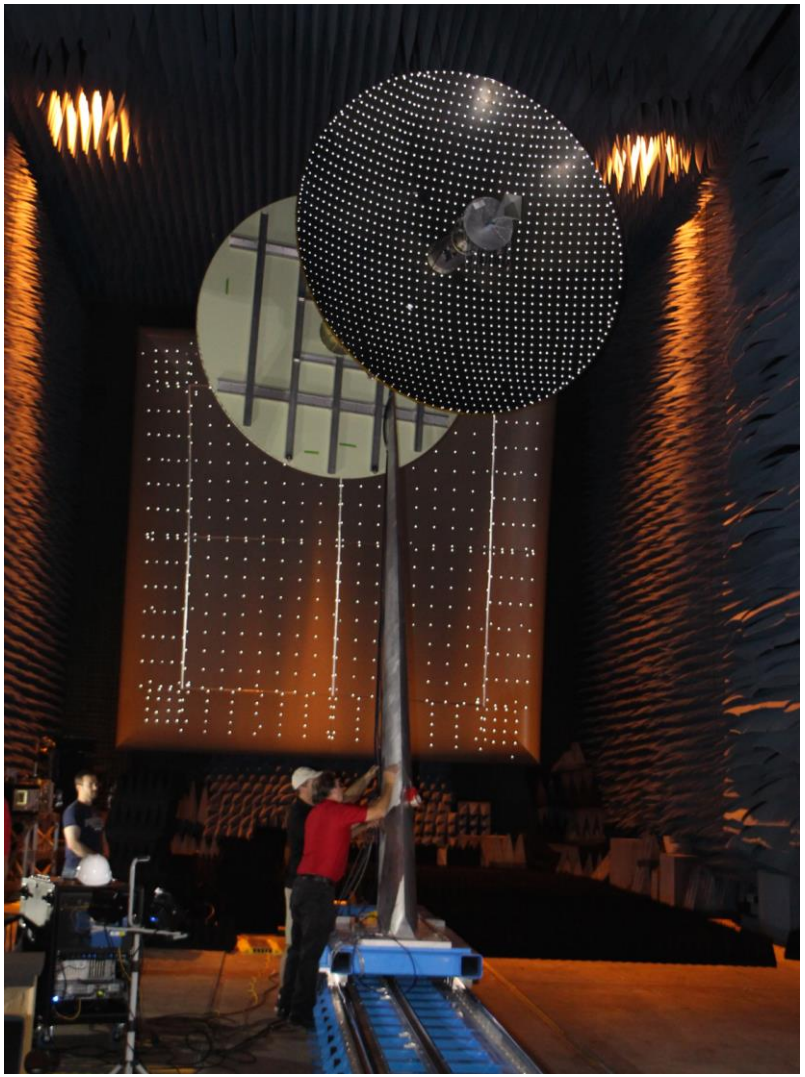
Prototype Hardware

Solar Array Panel Demonstrator



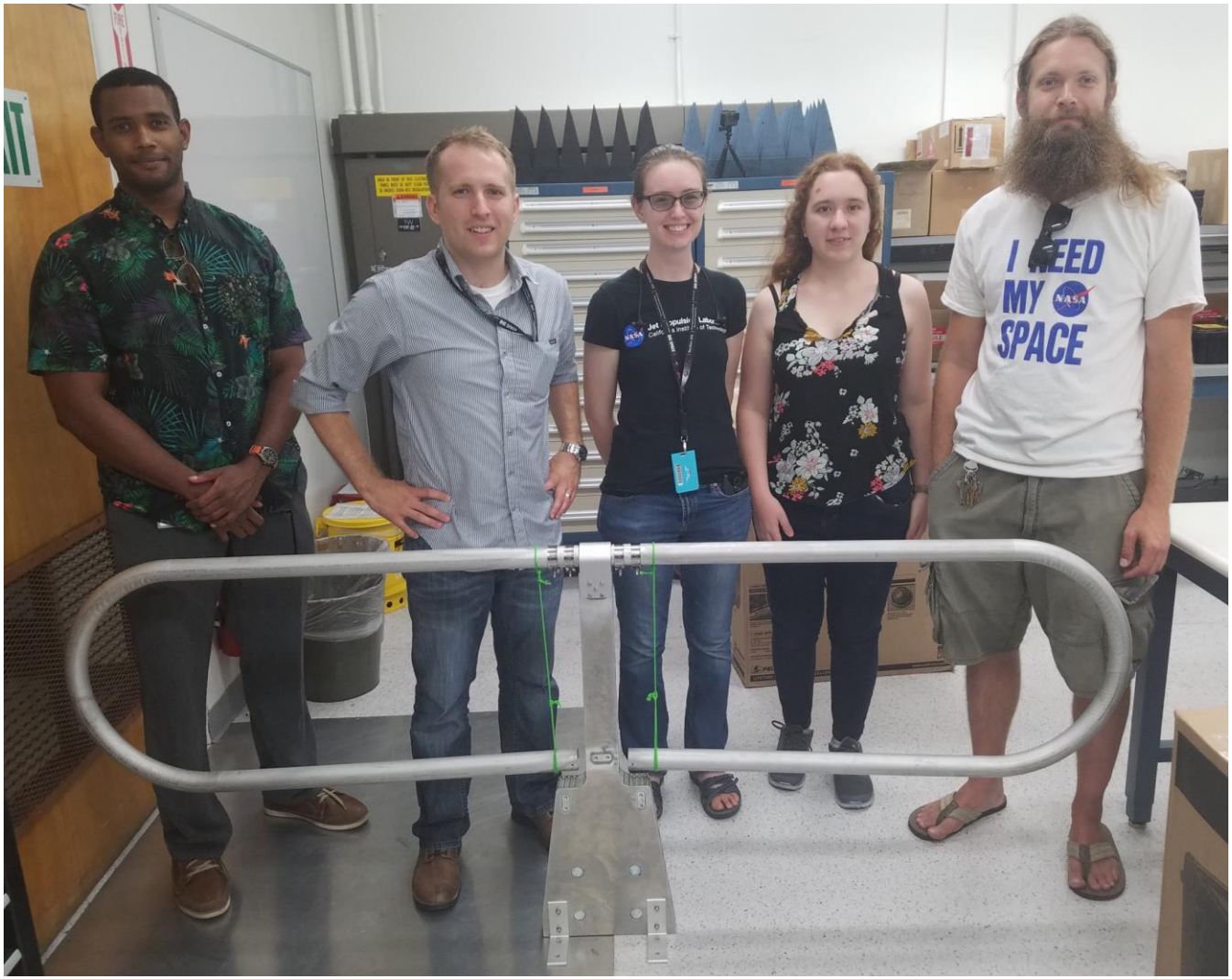
Prototype Hardware

High Gain Antenna



Prototype Hardware

REASON VHF Antenna



Instrument "Cost Triggers" for Cost Control

a) The Project has assigned each Instrument a cost number (A-D), deemed the "Cost Trigger," to determine when action needs to be taken to assure that the instrument maintains cost control
   - Scope growth imposed on instruments from other areas within the Project as determined by the PM, or any approved lien, will raise an instrument's "Cost Trigger"

b) If the Project has determined that an instruments Cost Trigger will be reached, the instrument PI/IM will evaluate and implement previously proposed de-scope actions that can be taken to reduce cost without impacting Level-1 requirements

c) If no action can be taken to reduce the instruments A-D cost below the Cost Trigger without impacting Level-1 science requirements as determined by the Project Scientist, then the Project Manager will assess the budgetary situation and determine if the instruments Cost Trigger should be raised by encumbering Project UFE

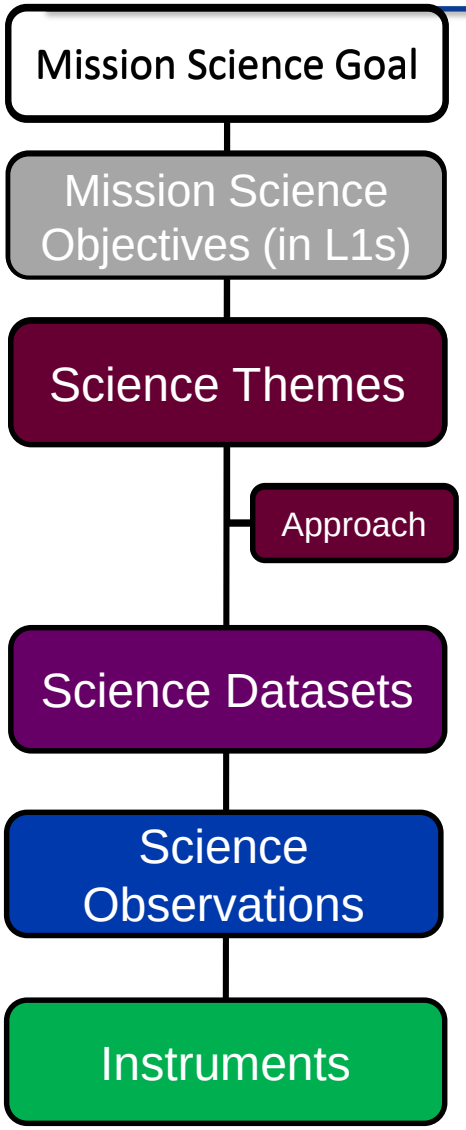
d) If the answer to step (c) above is no, or the PI does not take action as described in step (b), a mandatory discussion on instrument de-scope(s) / performance reduction will be conducted
   - The outcome of this meeting shall be either a path to an instrument de-scope(s), or an action at HQ to schedule a Directorate level PMC to either request use of HQ held UFE or a modification to the Level-1 requirements accepting reduced performance

Project Science Traceability and Alignment Framework (P-STAF): Introduction

- The Project-Science Traceability and Alignment Framework (P-STAF) is a tool for codifying how the Europa Clipper science is planned to be achieved
  - Traces flow from the Level-1 Science Requirements to instrument measurements
  - Permits evaluation of instrument capability synergies and areas of overlap

- This P-STAF approach permits assessment of instrument contributions and robustness in achieving Level-1 Science Requirements, relevant to:
  - Deriving a decision framework to assess science impacts, when performing cost trades as part of instrument and mission development
  - Understanding implications of possible changes in instrument science scope
  - Evaluating implications of faults that might disrupt instrument observations during the science campaigns

Project Science Traceability and Alignment Framework (P-STAF): Taxonomy



P-STAF Domain

Breakdown of the L1 Requirements into Science Groupings

e.g. Ocean, Ice Shell

Different Ways to Address a Specific Theme

e.g. Induction, Sounding, Gravity

Grouping of Observations/Data from a Specific "Measurement Class" that Support a Specific Theme

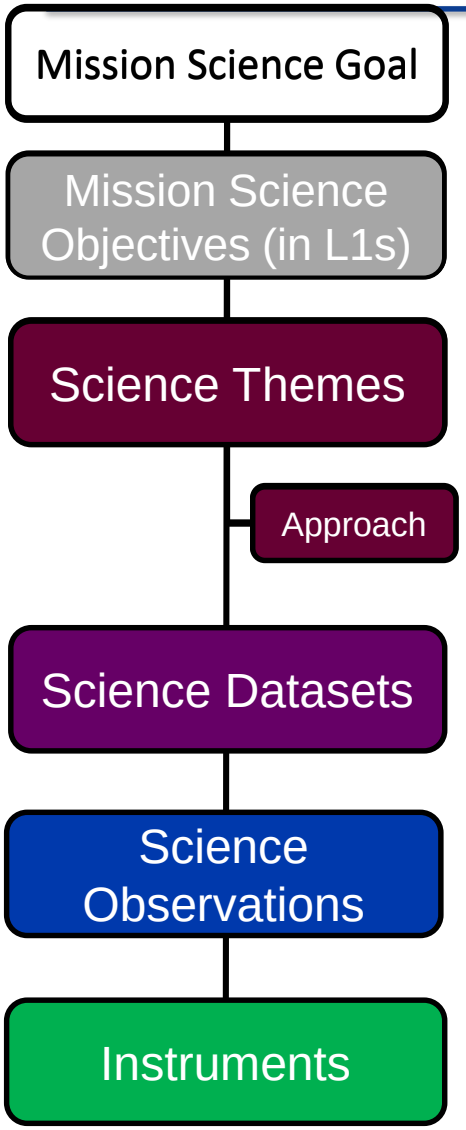
e.g. Landform Geology Visible Dataset; Landform Geology Radar Dataset

Unique Combination of Conditions and Techniques that Collect Data to Support Science

e.g. VHF Sounding; Surface Color Monoscopic Images; Impact Mass Spectrometry Endogenic Particles

- STAF framework offers:
  - Traceability
  - Completeness
  - Consistency across instruments
- STAF provides efficiency:
  - Prioritization
  - Tour analysis
  - Mission robustness analysis

Project Science Traceability and Alignment Framework (P-STAF)



Goal	Baseline L1 Req.	Science Themes	Baseline Approaches
Explore Europa to Investigate its Habitability	Subsurface structure of landforms (≥50)	Deep Subsurface Exchange	Sounding
		Shallow Subsurface Structure	Sounding
	Ice thickness; ocean salinity (±50%)	Ice Shell Properties	Induction, Sounding, Shape and Gravity
		Ocean Properties	Induction, Shape and Gravity
	Global comp. map (≥70%)	Global Compositional Surface Mapping	Complex Species and Units, Simple Species and Units
	Landform comp. (≥50%, ≤300 m)	Landform Composition	Complex Species and Units, Simple Species and Units
	Gas, dust, & plasma composition	Atmospheric Composition	Plasma, Complex Volatile Species, Simple Volatile Species, Particulates
		Space Environment Composition	Plasma, Complex Volatile Species, Simple Volatile Species, Particulates
	Global imaging map (≥80%)	Global Surface Mapping	Morphology
	High-res (≤25 m) landforms (≥50)	Landform Geology	Morphology, Topography
	Local surface (~1m, ≥40 sites)	Local-Scale Surface Properties	Morphology, Roughness and Permittivity
	Search for and characterize any current activity	Remote Plume Search and Characterization	Volatiles, Particulates
		In Situ Plume Search and Characterization	Atmospheric Particulates, Atmospheric Volatiles, Plasma
		Surface Thermal Anomaly Search	Thermal Emission
		Surface Activity Evidence	Deposits, Surface Changes

Science Synergy & Redundancy

High Level Roll-Up to Baseline Level-1 Science Requirements

Baseline L1 Req.	Science Themes	Radar		Visible		Infrared	Thermal	UV	Magnetic	Plasma	IMS	NMS	Gravity
		HF	VHF	NAC	WAC								
Subsurface structure of landforms (≥50)	Deep Subsurface Exchange	P	P	S	S								
	Shallow Subsurface Structure	P	P	S	S		E						
Ice thickness; ocean salinity (±50%)	Ice Shell Properties	I	I	S	S		E		P	S			E
	Ocean Properties			E	E	E			P	S	E	E	E
Global comp. map (≥70%)	Global Compositional Surface Mapping			E	E	P		E			E	E	
Landform comp. (≥50%, ≤300 m)	Landform Composition	E	E	E	E	P		I			E	E	
Gas, dust, & plasma composition	Atmospheric Composition	E	E			E		I	I	P	P	P	
	Space Environment Composition					E		P	I	P	P	P	
Global imaging map (≥80%)	Global Surface Mapping			P	P	E	E						
High-res (≤25 m) landforms (≥50)	Landform Geology	E	I	P	P	E	E	E			E	E	
Local surface (~1m, ≥40 sites)	Local-Scale Surface Properties	I	I	P	E		P						
Search for and characterize any current activity	Remote Plume Search and Characterization			P	I	E	E	P					
	In-Situ Plume Search and Characterization	E	E						I	P	P	P	
	Surface Thermal Anomaly Search	E	E	E	E	I	P						
	Surface Activity Evidence	I	I	P	P	I	I	I			E	E	

P Primary I Independent S Supporting E Enhancing

Full P-STAF Matrix (In Progress)

Mission Science Goal

Mission Science Objectives (in L1s)

Science Themes

Approach

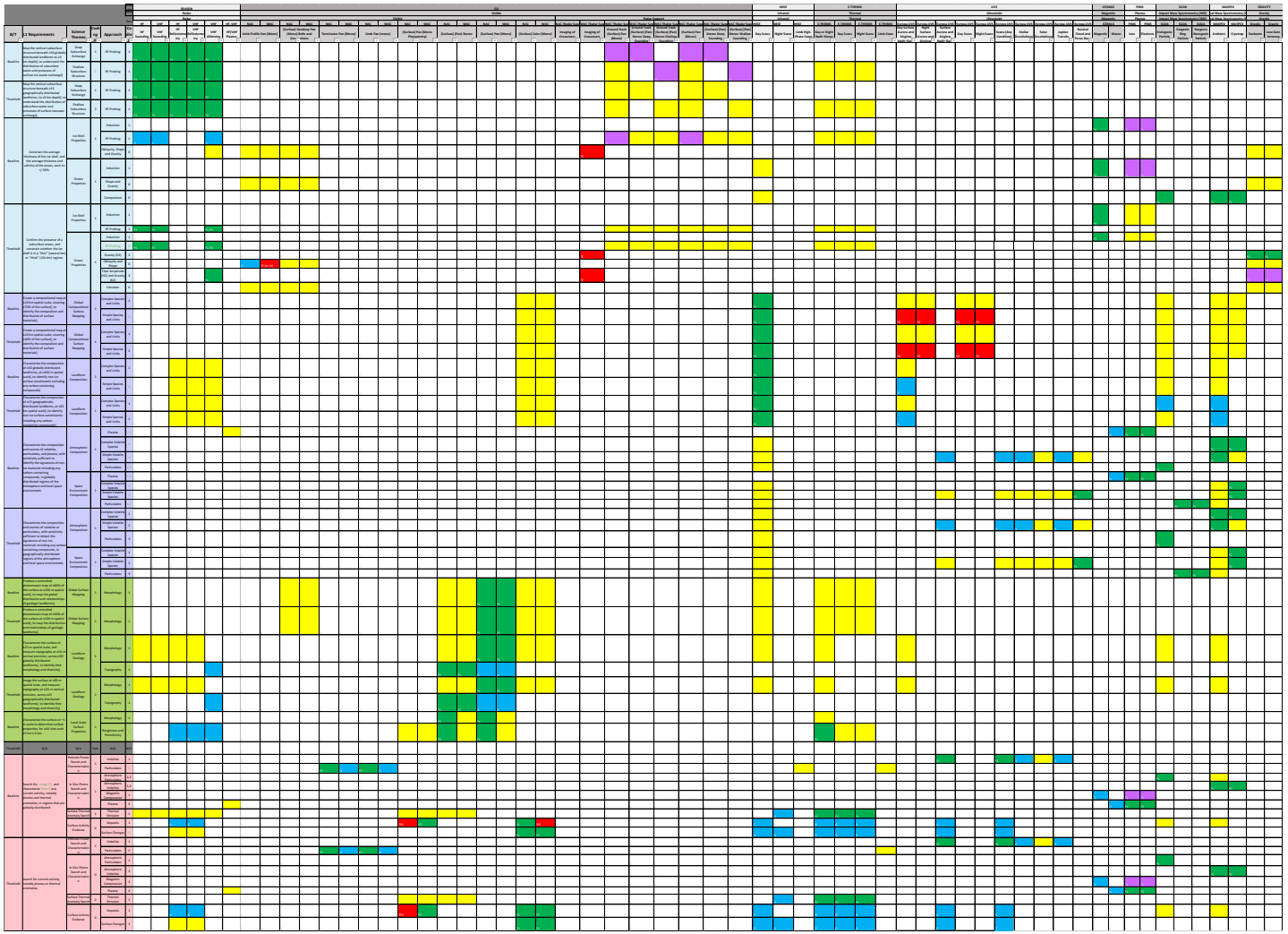
Science Datasets

Science Observations

Instruments

L1, Science Theme, Approach

Science Observations by Measurement Class



- **P** — Primary
- **I** — Independent
- **S** — Supporting
- **E** — Enhancing
- **?** — In Progress

- A primary instrument (P) is not required in every row.
- If an approach has no primary instrument, then that approach is considered less robust.

P-STAF Analysis (Still To Come)

Once the inputs are reconciled and vetted, the P-STAF can be used to determine:

"Simple" queries to the network include:

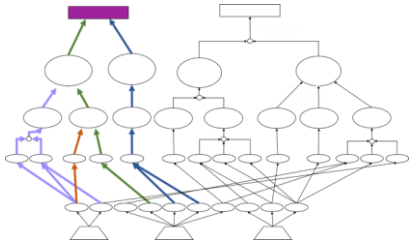
- In how many independent ways can each Level 1 be met?
- Which Level 1s have single points of failure?
- If an instrument or observation fails, which Level 1s are not achievable?
- How many paths does an instrument or observation affect?

"Complex" queries to the network include:

- How resilient is each Level 1 to failures?
- What is the impact of a given observation or instrument?
- What is the minimum set (of instruments or observations) necessary to meet a Level 1 or a group of Level 1s?
- Which Level 1s require the most resources to meet?

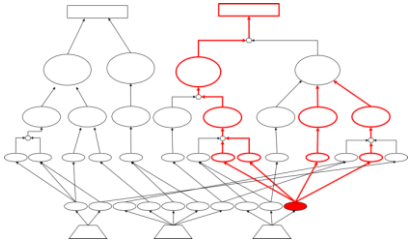
Robustness

Number of Viable Paths



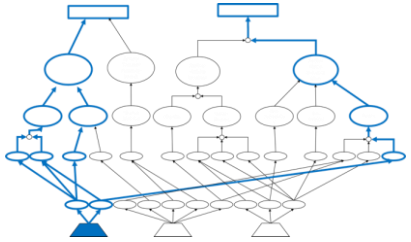
Criticality

Single Point Failures



Scope

Link Density of Nodes



How the P-STAF Can Inform Decisions that Affect Science

- P-STAF approach provides a standard format from which Level-1 Science requirements can be traced, via science themes, to instrument measurements
- Permits assessment of the contribution (Primary, Independent, Supportive, and Enhancing) of individual instrument measurements to each Science Theme, and thus each Level-1 Science requirement
- Provides a decision-tree structure that can aid assessment of the science impact when considering modifications to the instrument capabilities or complement
- In making capability trades as may be necessary for cost control, P-STAF provides a simple and concrete means to evaluate the potential impact to achieving Level-1 Science Requirements